Concurrent Monitoring, Analysis, and Visualization of Freeway and Arterial Performance for Recurring and Non-recurring Congestion

For Presentation at the NATMEC 2010 Session on:

Congestion Monitoring and Analysis: Tools and Techniques, Part 2

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Overview

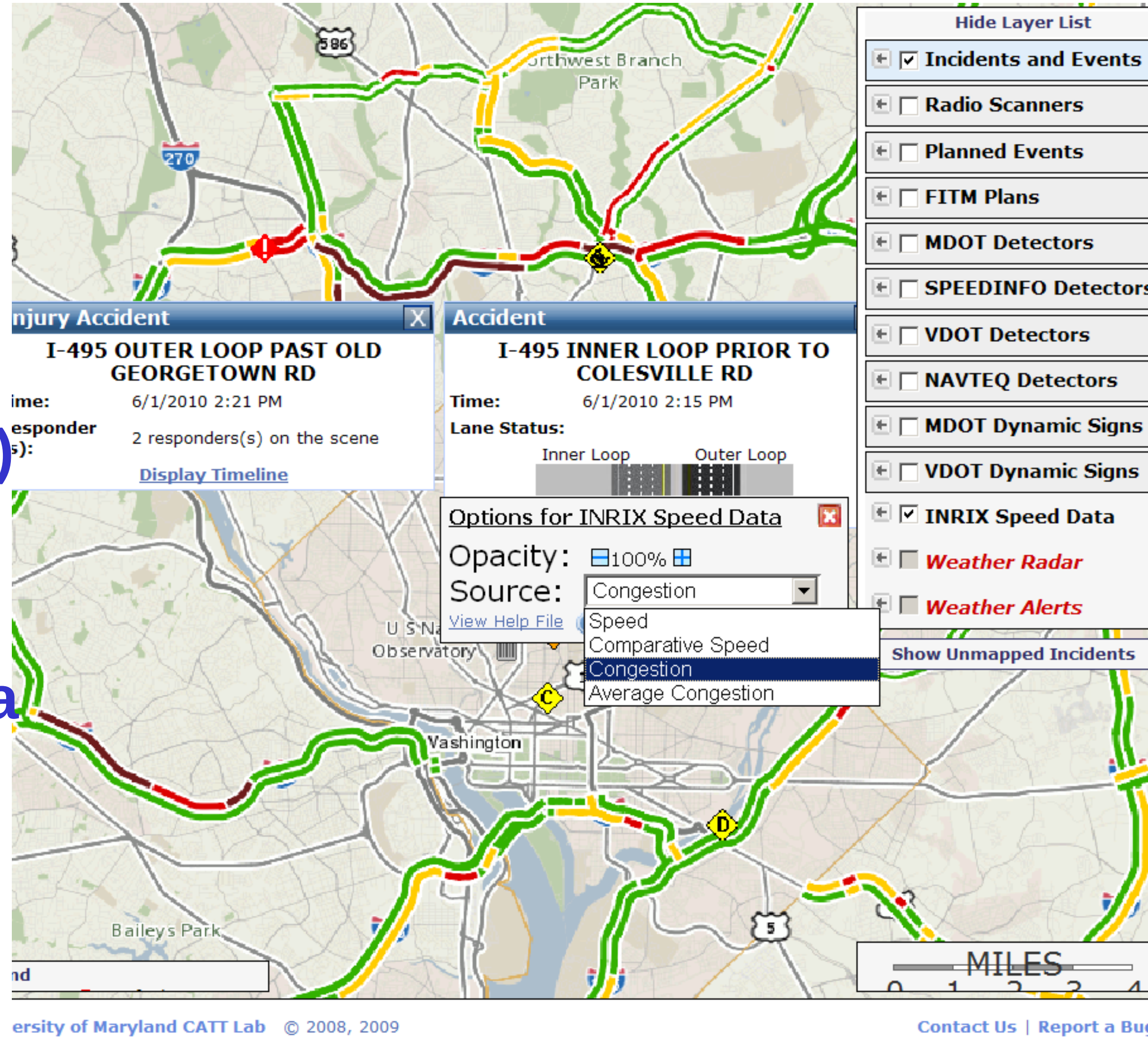
- I-95 Corridor Vehicle Probe Project (VPP) data being used to monitor and analyze congestion
- Most work has dealt with non-recurring congestion; newer work on recurring congestion
- Focus on visualization tools and techniques
- Give 3 examples using the Regional Integrated Transportation Information System (RITIS)
- Integrating data on arterials along with freeway performance is presenting new challenges
- Presentation blends these two congestion monitoring and analysis considerations

I-95 Corridor Coalition VPP Data

- RITIS is being used as a database management system for the VPP data
- Focus on current time use of the data; use of the archived data is now starting to happen
- Emphasis has been on the selected freeways; but there is limited coverage
- Coverage on arterials is even more limited
- INRIX has more coverage, but not part of the purchase

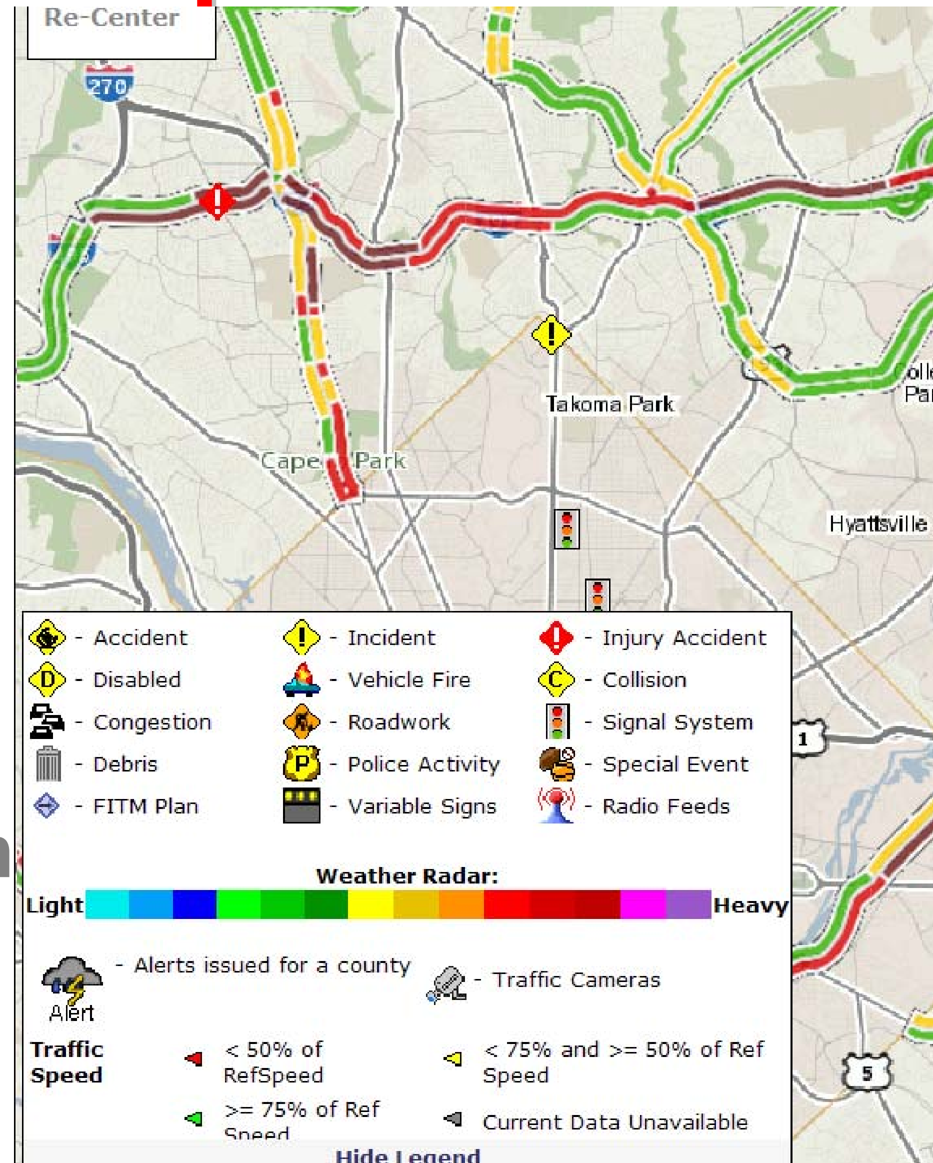
RITIS Integrates many Data Sources

- Data from flow detectors of many public agencies
- Data from other private sources (i.e. NAVTEQ, SpeedInfo)
- Focus on incident related Data
- Weather related Data
- Transit related data beginning to be worked on too



RITIS has its own Representations

- "Speed Map" displays with some ability to tailor break-points
- Incident icons
- Overlays of weather events
- Incident "time-lines"
- Distance vs. speed "contour" displays from the archived data
- Other visualization tools



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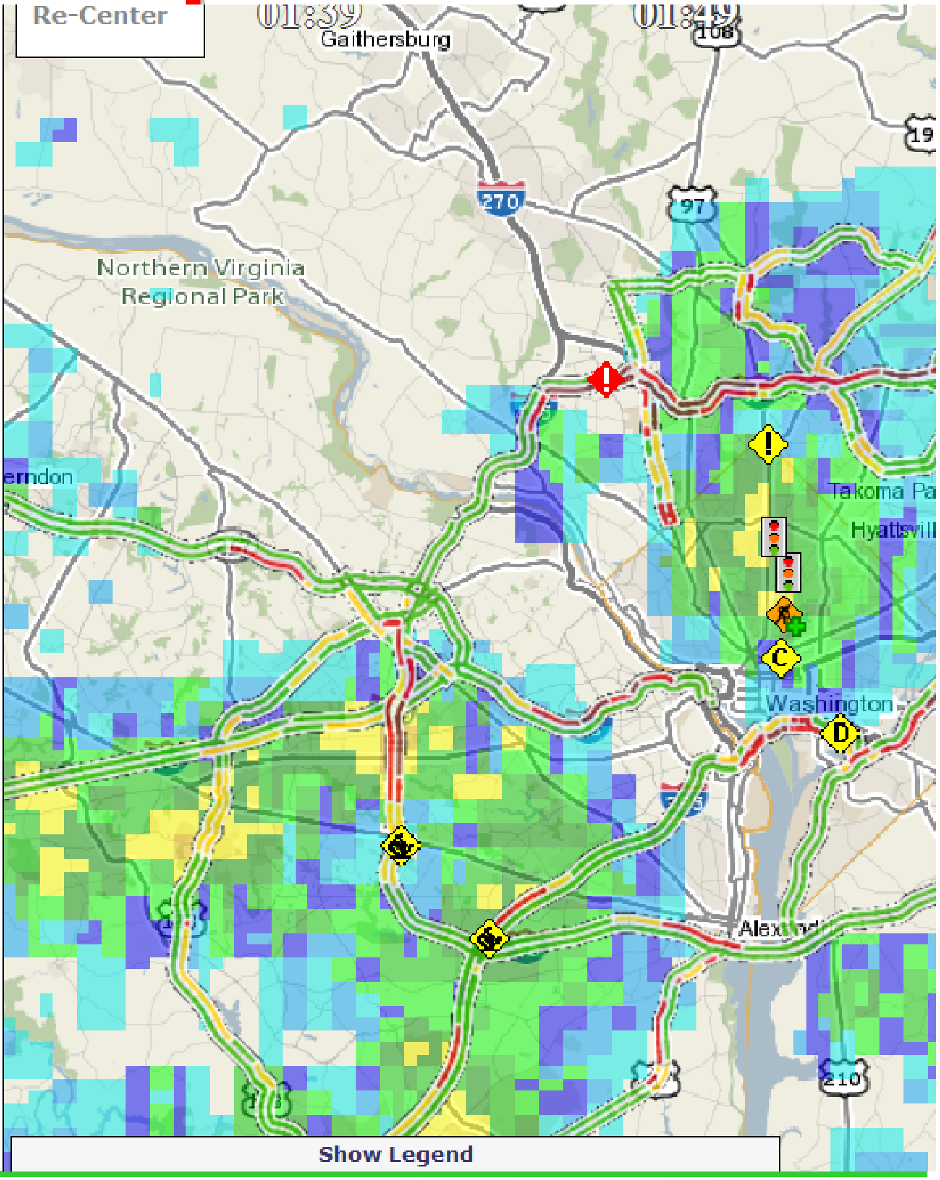
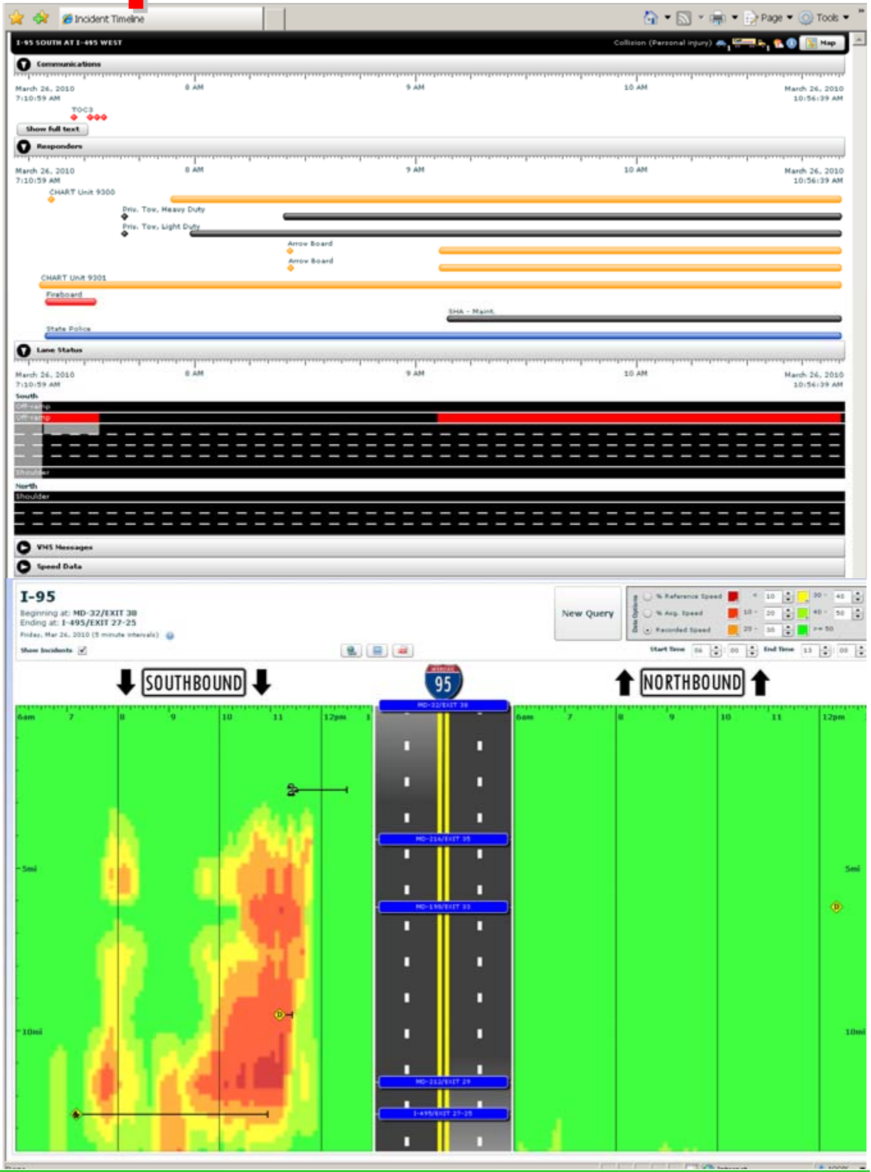


RITIS has its own Representations

- "Speed Map" displays with the ability to tailor break-points
- Incident icons
- Overlays of weather events
- **Incident "time-lines"**
- **Distance vs. speed "contour" displays from the archived data**
- There also are other visualization tools



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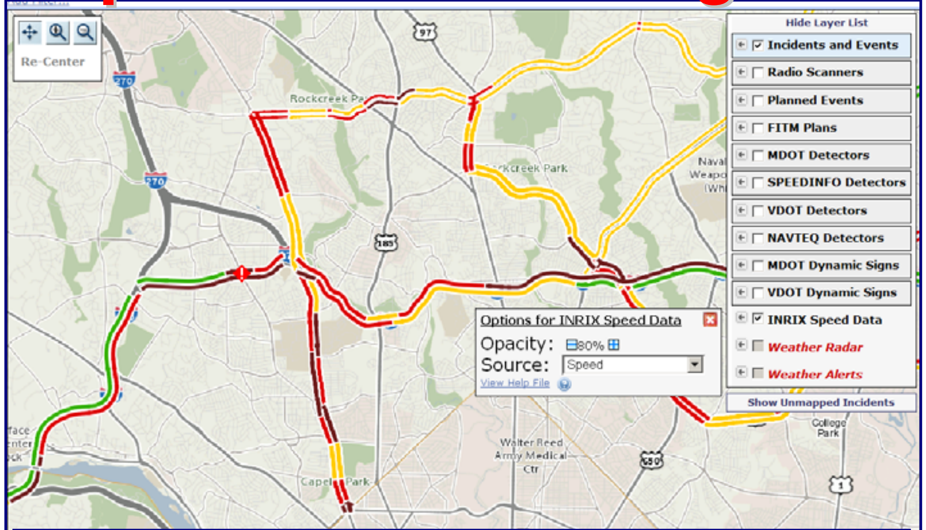
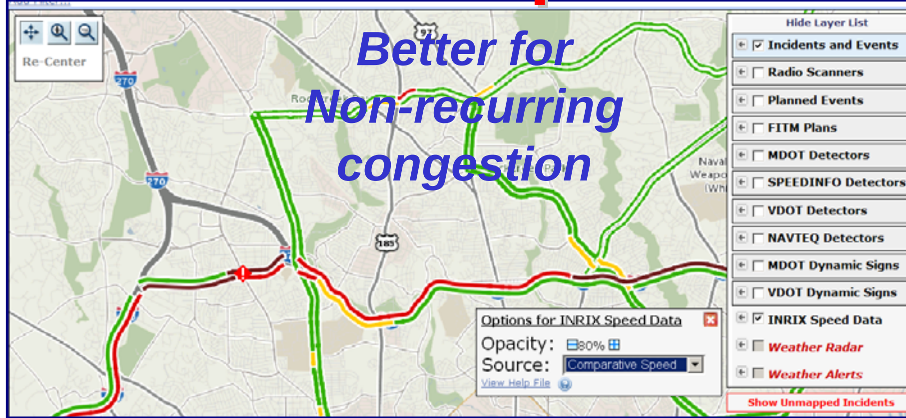
Speed Map Visualizations – Users can Select 1 of 4 Speed-Range-Scales

- **“Speed”:** current speed of the segment in MPH
- **“Comparative Speed”:** current speed of the segment compared to the average speed recorded for that hour of the day and day of week *(better shows non-recurring congestion)*
- **“Congestion”:** current speed of the segment compared to the calculated speed of traffic on that road when there is no congestion (reference speed) *(better for recurring congestion)*
- **“Average Congestion”:** The average speed compared to the calculated speed of traffic on that road when there is no congestion (reference speed)

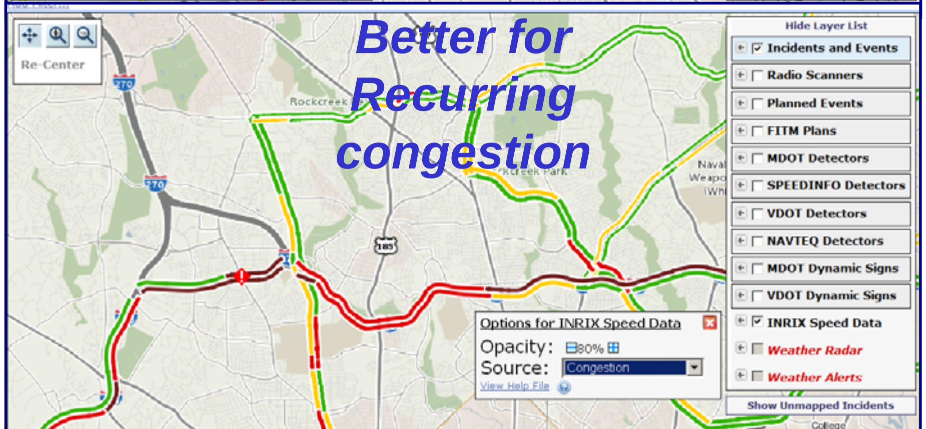
Impression of "congestion" varies with Speed-scale



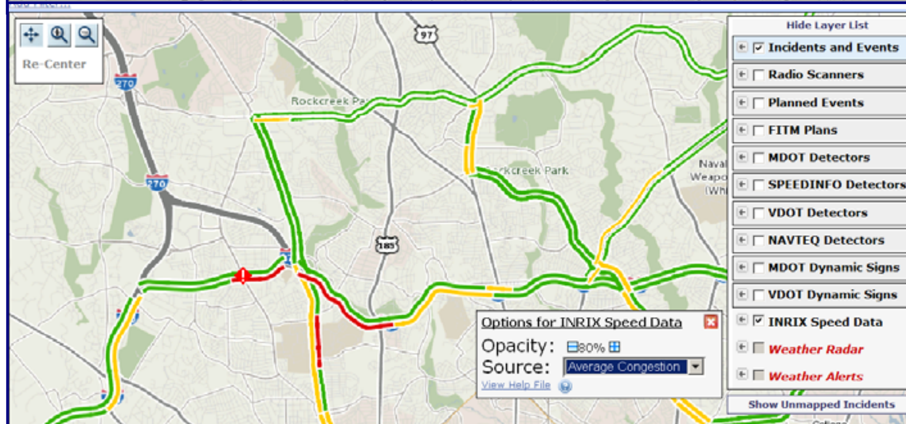
"Speed" current speed of segment in mph



"Comparative Speed" current speed of the segment vs. the average speed recorded for that hour of the day and day of week



"Congestion" current speed of segment vs. calculated speed of traffic on that road when there is no congestion (ref. speed)



"Average Congestion" average speed vs. calculated speed of traffic on that road when there is no congestion (ref. speed)

Arterials: Further refinement is needed

- **Red-Yellow-Green speed map displays,** based on freeways; often from lane-occupancy data from traffic flow detectors at fixed-locations
- **Probe-based speed** generally use TMC coded links used by in-vehicle navigation systems
- **TMC links** seem better suited for representing flow on freeways than on arterials with interrupted flow
- **Arterial Level of Service** – understanding ways that performance of arterials is usually described can lead to a better representation using the available data
- **Average Speed on Arterials** – concerned that need to use a different speed-scale than used for freeways
- **Not just a VPP-based Concern**: speed ranges used for fixed-location speed detectors on arterials have the same issue

Comparing Freeway with Arterial Level of Service

- Freeway LOS uses free flow speeds
- Four curves; six LOS categories
- Uninterrupted flow conditions
- Speed, volume, flow relationships

- Arterial LOS uses free flow speeds
- Four classes; six LOS categories
- Interrupted flow conditions
- Art. LOS about half freeway speeds

From Exhibit 23-3 Speed-Flow Curves for Basic Freeway Segments (Source: Highway Capacity Manual (2000))

	Urban Freeways "Speed-Flow Curves" by Free Flow Speed							
Typical Free Flow Speed	80 mph		70 mph		65 mph		60 mph	
Level of Service	Average Travel Speed (mph)							
A	>	68	>	60	>	55	>	50
B	56	68	50	60	45	55	40	50
C	44	56	40	50	35	45	30	40
D	32	44	30	40	30	35	24	30
E	20	32	20	30	20	30	18	24
F	=<	20	=<	20	=<	20	=<	18

Based on Exhibit 15-2 Urban Street Level of Service by Class (Source: Highway Capacity Manual (2000))

Class	I		II		III		IV	
Free Flow Speed Range	55 to 45 mph		45 to 35 mph		35 to 30 mph		35 to 25 mph	
Typical Free Flow Speed	50 mph		40 mph		35 mph		30 mph	
Level of Service	Average Travel Speed (mph)							
A	>	42	>	35	>	30	>	25
B	34	42	28	35	24	30	19	25
C	27	34	22	28	18	24	13	19
D	21	27	17	22	14	18	9	13
E	16	21	13	17	10	14	7	9
F	=<	16	=<	13	=<	10	=<	7

Comparing Fwy-Art as a Percent of Free Flow Speed

- Freeway LOS uses free flow speeds
- Four curves; six LOS categories
- Uninterrupted flow conditions
- Speed, volume, flow relationships

- Arterial LOS uses free flow speeds
- Four classes; six LOS categories
- Interrupted flow conditions
- <u>Similar percent of Free Flow Speed</u>

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	Urban Freeways "Speed-Flow Curves" by Free Flow Speed							
Typical Free Flow Speed	80 mph		70 mph		65 mph		60 mph	
Level of Service	Average Travel Speed (mph)							
A	>	68	>	60	>	55	>	50
B	56	68	50	60	45	55	40	50
C	44	56	40	50	35	45	30	40
D	32	44	30	40	30	35	24	30
E	20	32	20	30	20	30	18	24
F	=<	20	=<	20	=<	20	=<	18

Level of Service	Average Rolling Delay Relative to Free Flow Speed (as a Percent)							
A	>	85%	>	86%	>	85%	>	83%
B	70%	85%	71%	86%	69%	85%	67%	83%
C	55%	70%	57%	71%	54%	69%	50%	67%
D	40%	55%	43%	57%	46%	54%	40%	50%
E	25%	40%	29%	43%	31%	46%	30%	40%
F	=<	25%	=<	29%	=<	31%	=<	30%

Based on Exhibit 15-2 Urban Street Level of Service by Class (Source: Highway Capacity Manual (2000))

Class	I		II		III		IV	
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A	>	42	>	35	>	30	>	25
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D	21	27	17	22	14	18	9	13
E	16	21	13	17	10	14	7	9
F	=<	16	=<	13	=<	10	=<	7

Level of Service	Average Rolling Delay Relative to the Typical Free Flow Speed (as a percent)							
A	>	84%	>	88%	>	86%	>	83%
B	68%	84%	70%	88%	69%	86%	63%	83%
C	54%	68%	55%	70%	51%	69%	43%	63%
D	42%	54%	43%	55%	40%	51%	30%	43%
E	32%	42%	33%	43%	29%	40%	23%	30%
F	=<	32%	=<	33%	=<	29%	=<	23%

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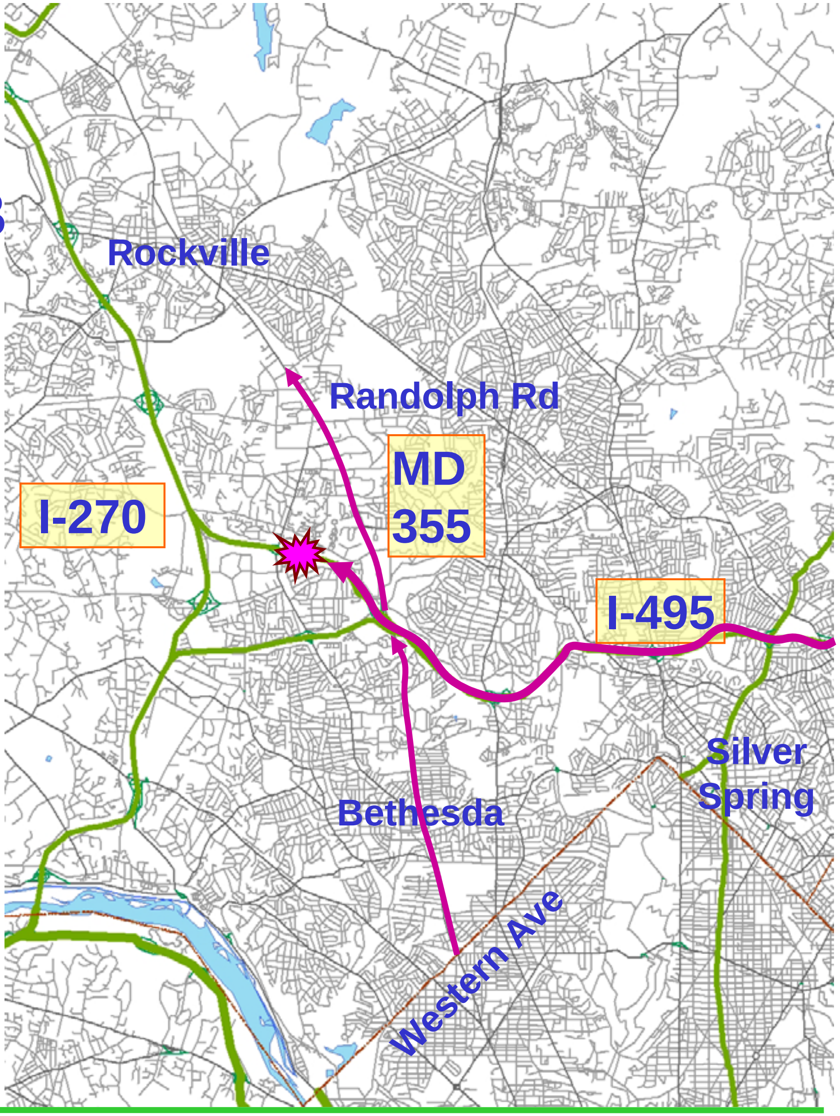
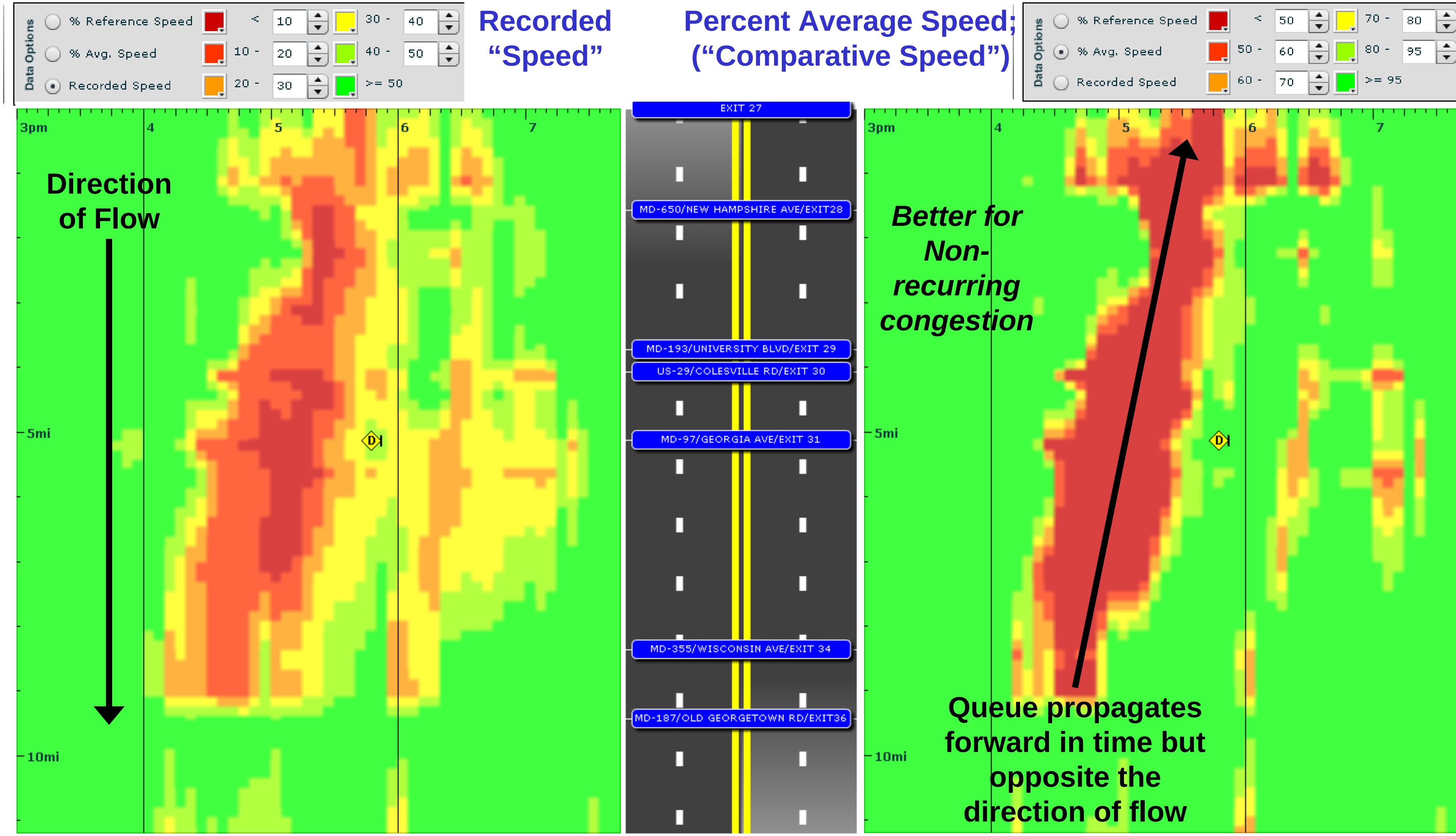
Example #1: I-495 (Freeway) Westbound diverts to MD 355 (Class III Arterial) northbound

- **Incident on I-270 NB backs up traffic onto I-495 and traffic diverts to the arterial MD 355 NB**
- **I-270 is not part of the data set but I-495 and MD 355 to the north of Randolph Road are**
- **Graphics that follow show the back-up on I-495 and then the congestion on MD 355 due to the diverted traffic**
- **Example to better understand how arterial speed ranges differ from freeway speed ranges**



Incident in PM Peak on I-270 NB affects traffic on I-495 Outerloop (not usual PM Peak)



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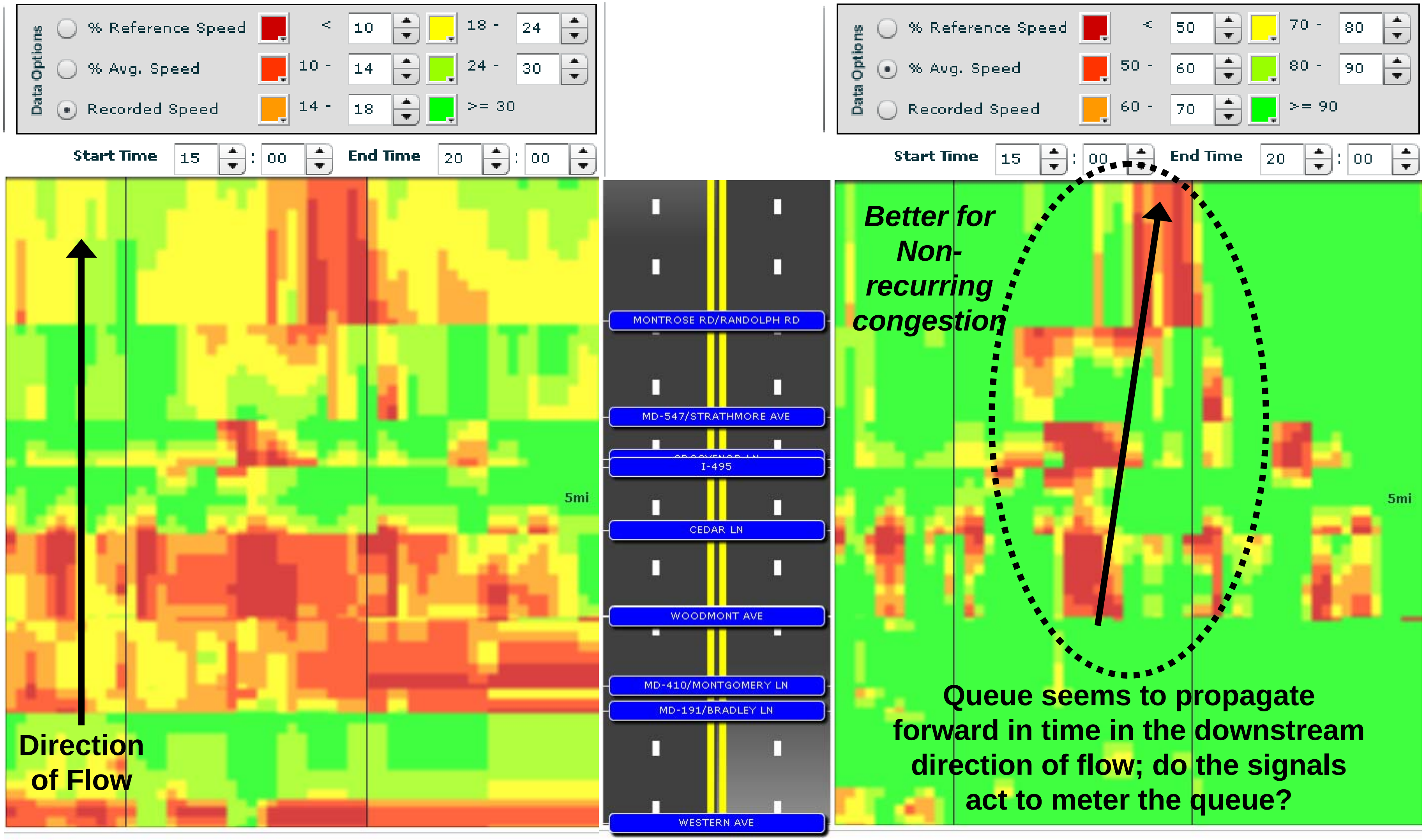
Incident in PM Peak on I-270 NB affects traffic on "parallel" Class III Arterial of MD 355 (northbound)

Recorded "Speed" for a Class III Arterial | **Percent Average Speed; ("Comparative Speed")**



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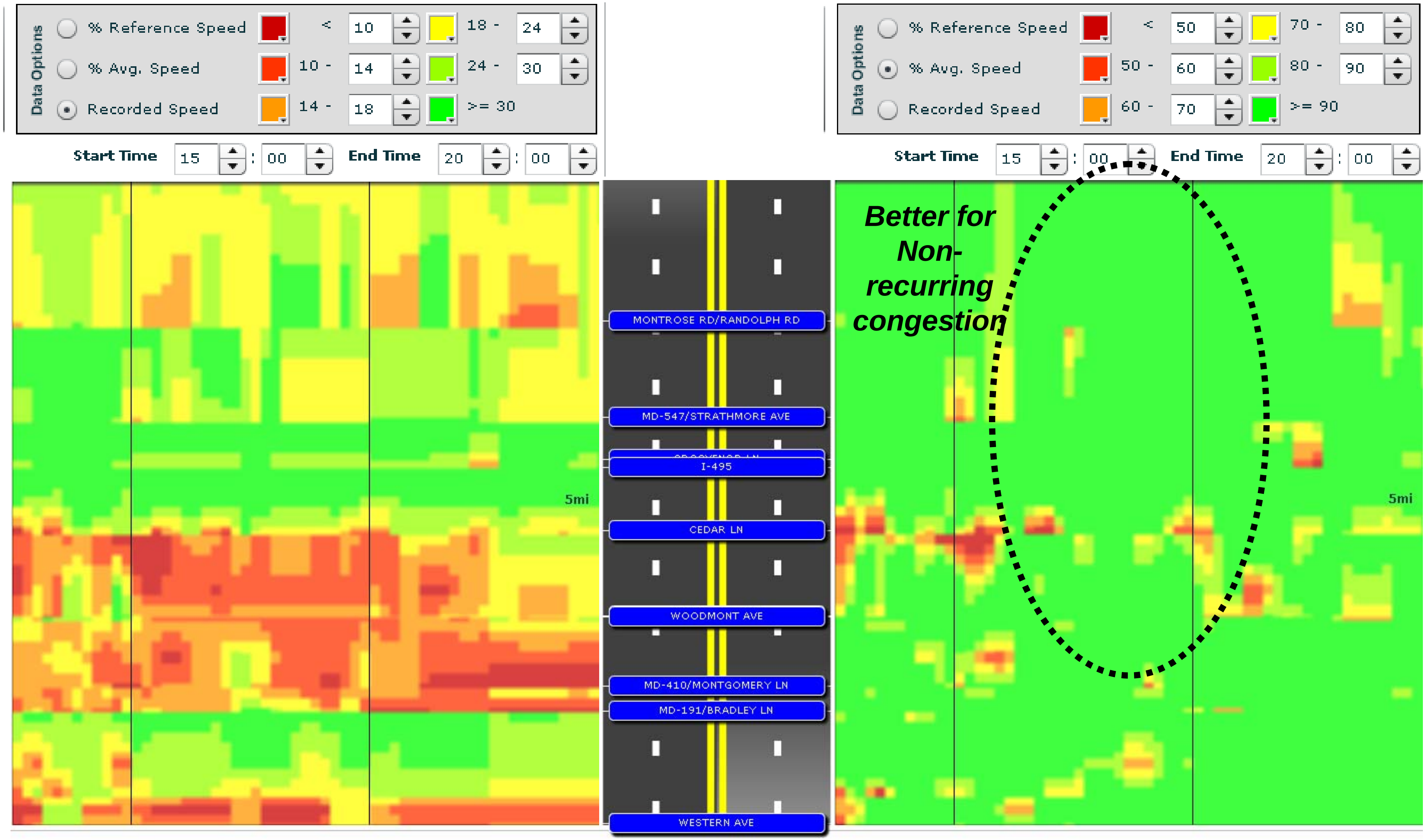
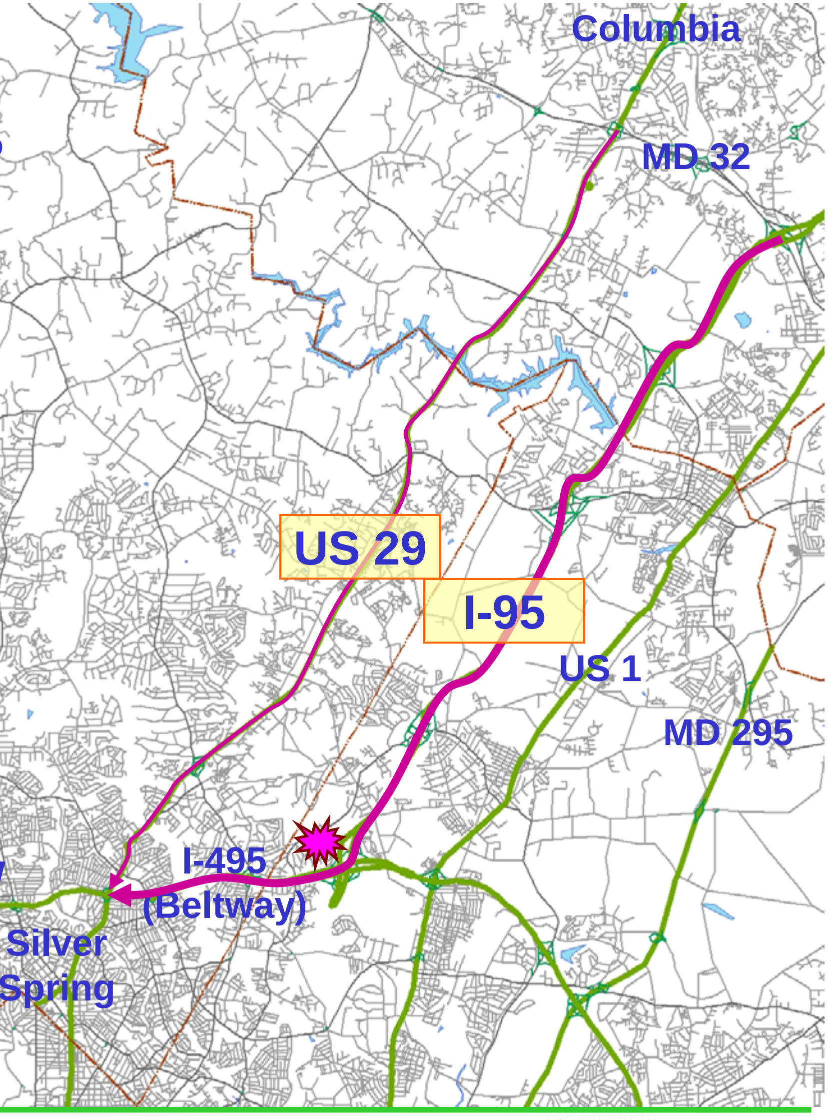
Example for the same time period for the week before shows mainly recurring congestion

Recorded "Speed" for a Class III Arterial | **Percent Average Speed; ("Comparative Speed")**



Example #2: I-95 (Freeway) Southbound compared to US 29 (Class I and III Arterial) Southbound

- Clearing of an incident near beginning of AM peak on I-95 SB was delayed to after the peak
- Traffic on parallel arterial SB US 29 during the incident as well as the clearance was affected
- Archived speed data can be used to help distinguish between recurring and non-recurring congestion
- Also help better understand how arterial speed scales relate to but differ from freeway speeds



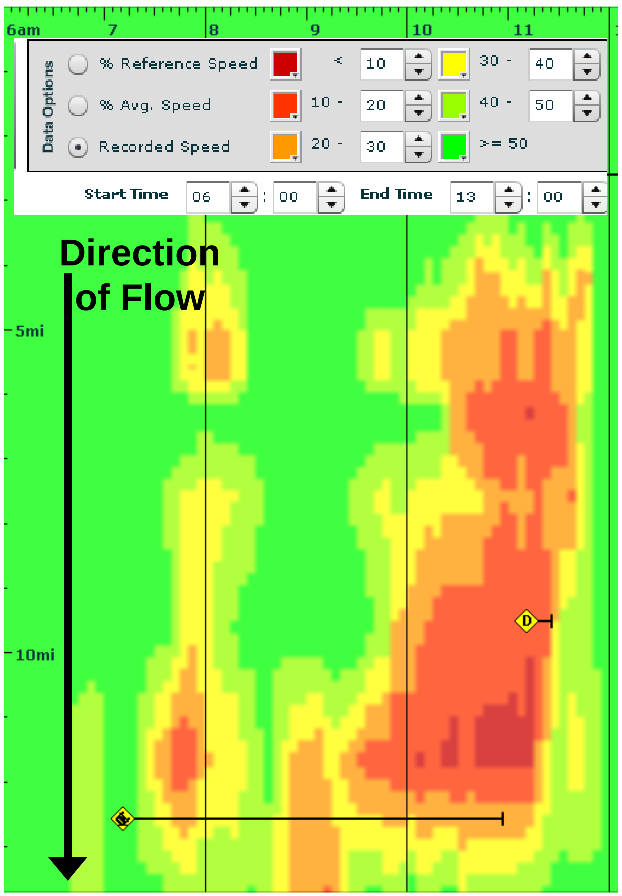
Incident in AM Peak carries over to Mid-day and affects traffic on parallel Class I Arterial of US 29

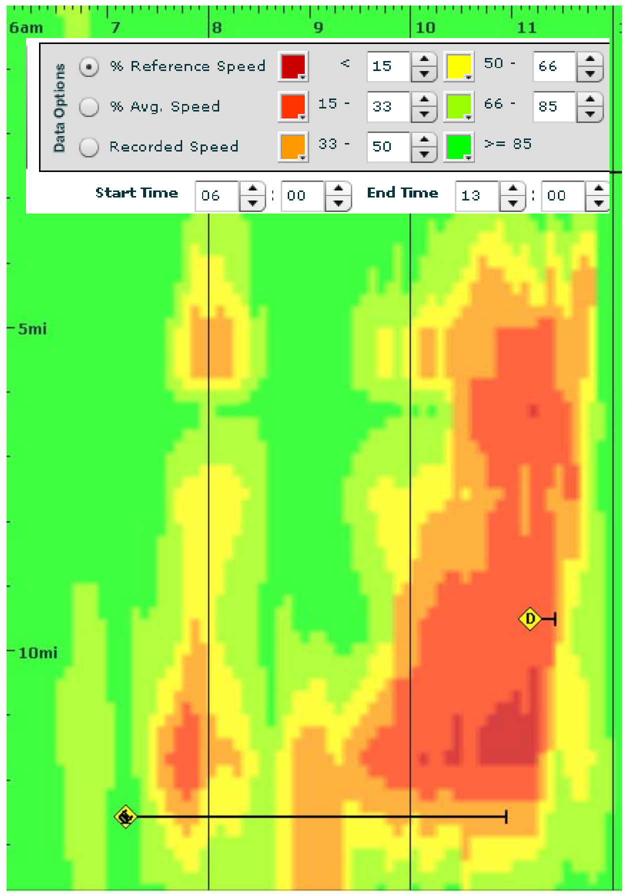
I-95

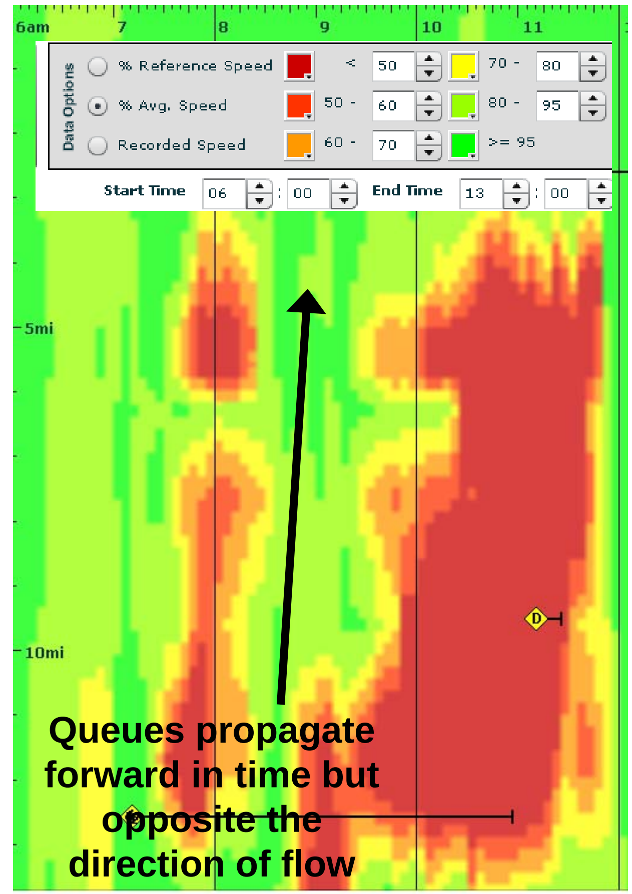
Beginning at: MD-32/EXIT 38
Ending at: I-495/EXIT 27-25
Friday, Mar 26, 2010 (5 minute intervals)

Show Incidents ☑

Recorded "Speed" ⬇ SOUTHBOUND ⬇	*Better for Recurring congestion* Percent Reference Speed ("Congestion")	*Better for Non-recurring congestion* Percent Average Speed; ("Comparative Speed")







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Arterial recorded & reference speed-scales show recurring congestion; % Avg. Speed needed to show Incidents Impacts

US-29

Beginning at: **MD-32/EXIT 16**
Ending at: **I-495**
Friday, Mar 26, 2010 (5 minute intervals)

Show Incidents ☑

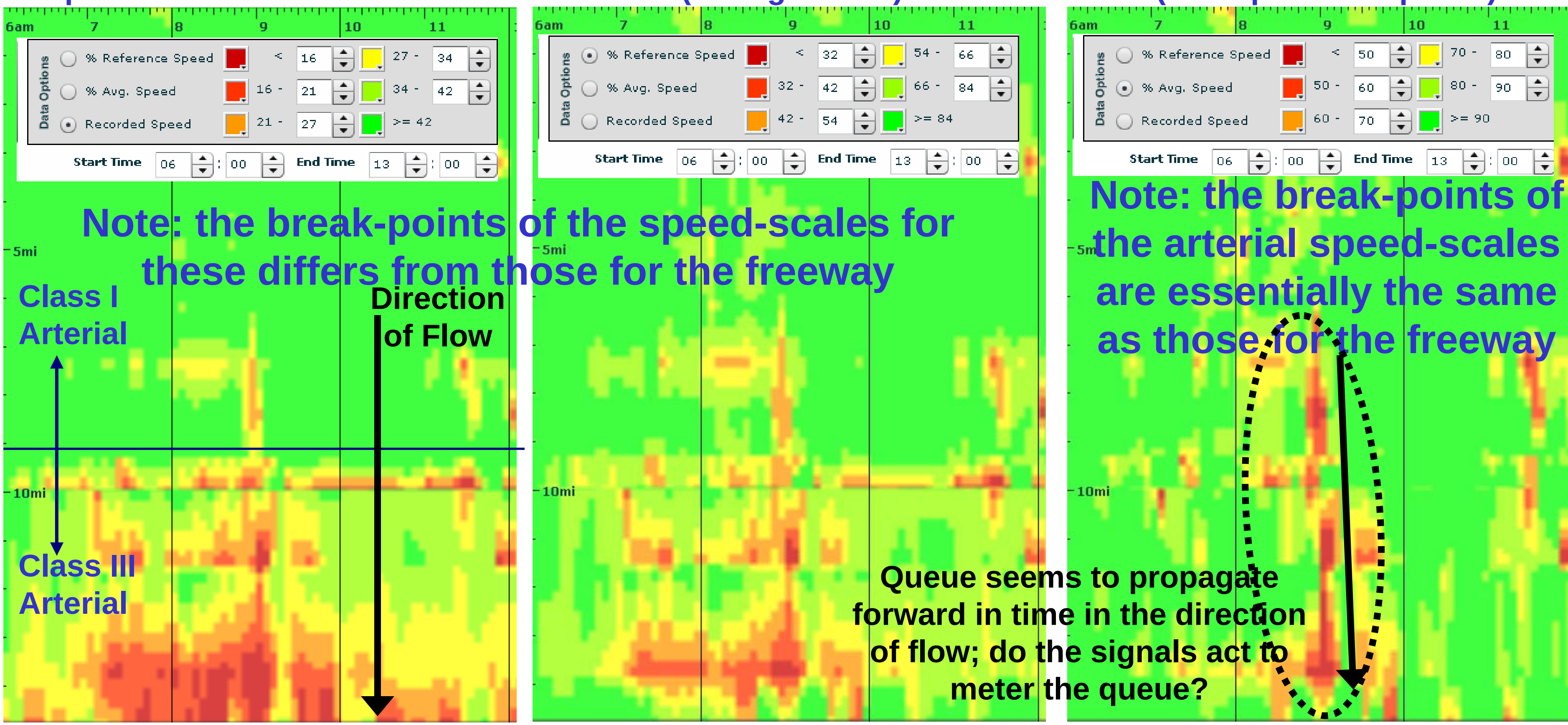
Recorded "Speed" ⬇ SOUTHBOUND ⬇

Better for Recurring congestion

Percent Reference Speed ("Congestion")

Better for Non-recurring congestion

Percent Average Speed; ("Comparative Speed")



Example for the same time the week before shows mainly recurring congestion; non-recurring congestion of a minor incident

US-29

Beginning at: **MD-32/EXIT 16**
Ending at: **I-495**
Friday, Mar 19, 2010 (5 minute intervals)

Show Incidents ☑

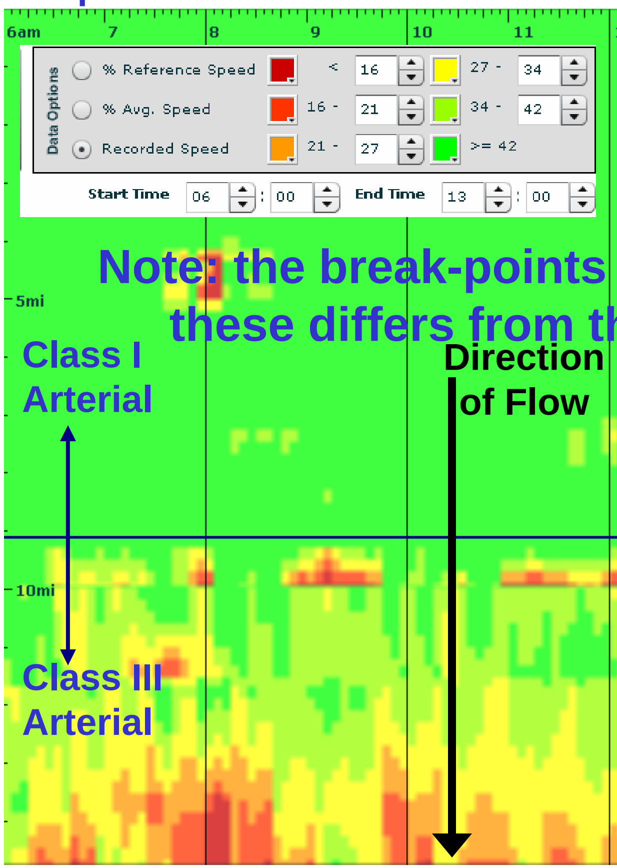
Recorded "Speed" ⬇ SOUTHBOUND ⬇

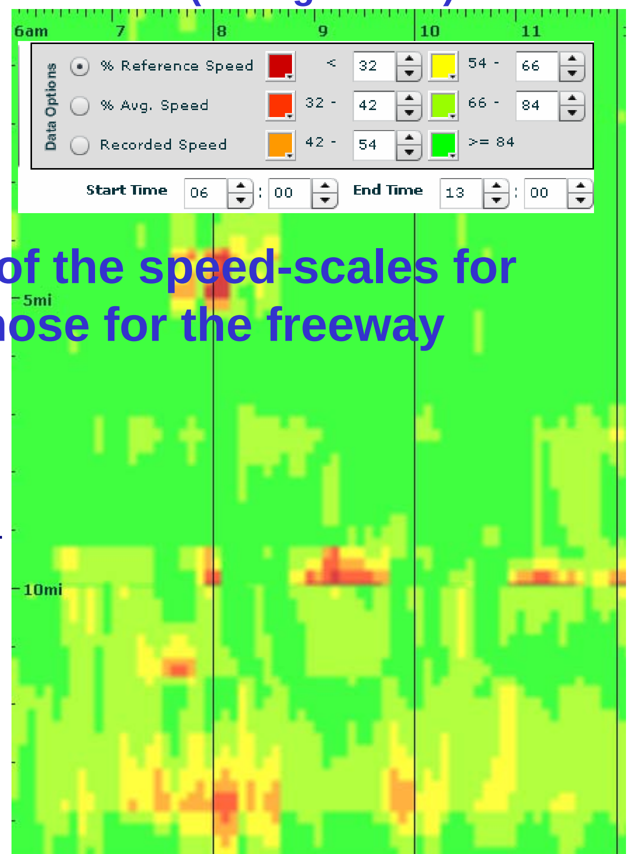
Better for Recurring congestion

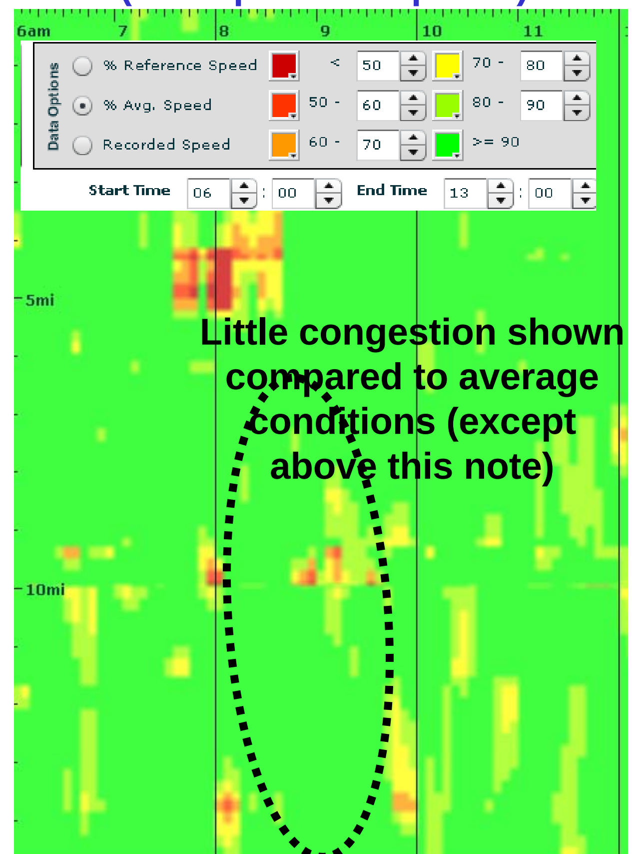
Percent Reference Speed ("Congestion")

Better for Non-recurring congestion

Percent Average Speed; ("Comparative Speed")







Note: the break-points of the speed-scales for these differs from those for the freeway

Class I Arterial

Class III Arterial

Direction of Flow

Little congestion shown compared to average conditions (except above this note)

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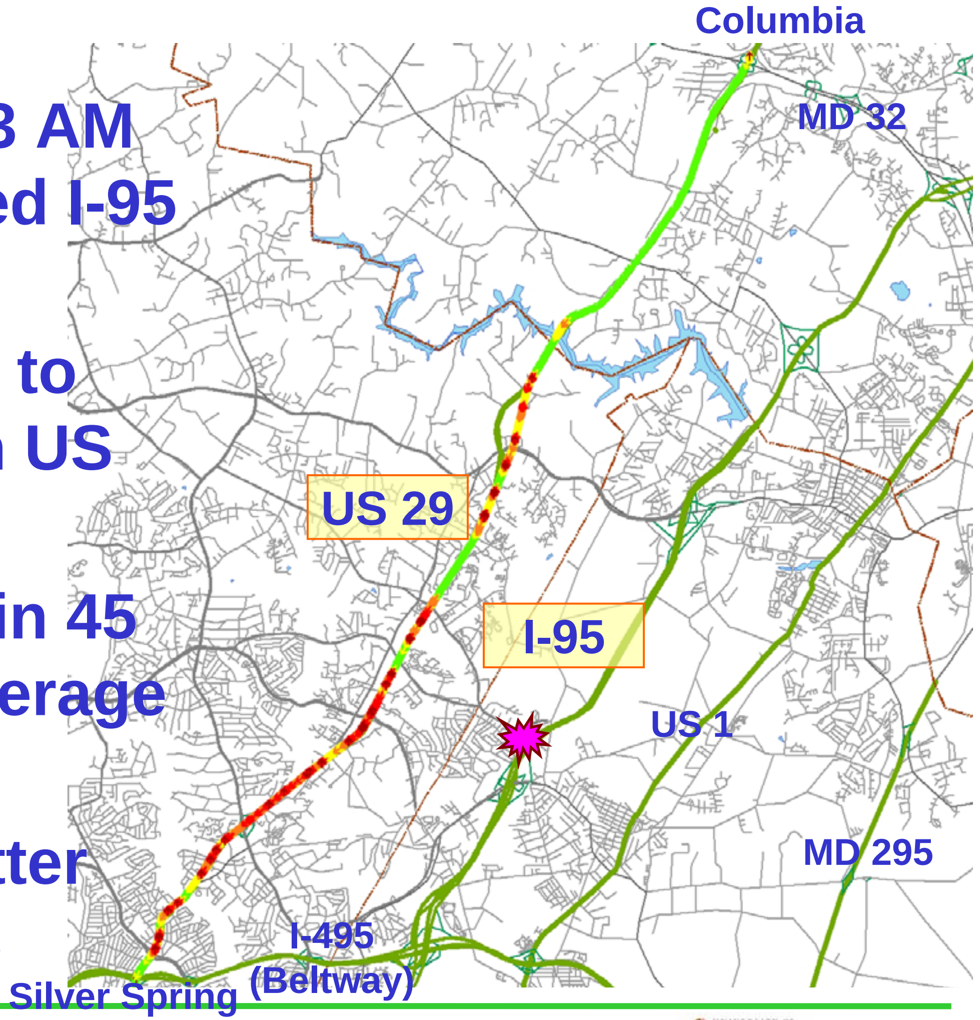
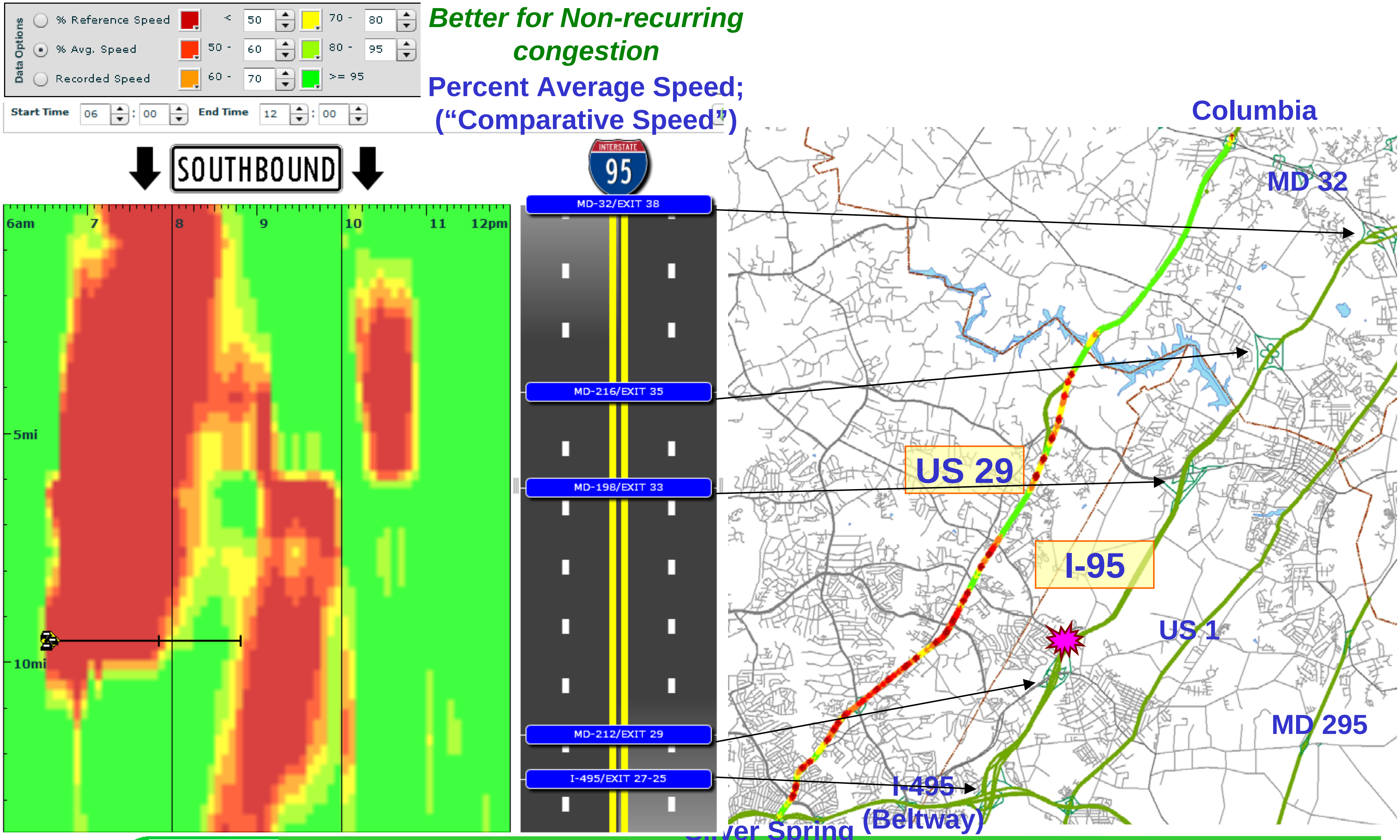
<u>Example #3</u>: I-95 (Freeway) Southbound compared to US 29 (Class I and III Arterial) Southbound

- Another example with the second freeway-arterial on 6-8-10
- Multi-car crash at about 6:33 AM lasted for 75 min and jammed I-95 southbound past MD 32
- By happenstance I was able to observe a GPS trajectory on US 29 starting at about 9:00 AM
- The trip on US 29 took 40 min 45 sec for the 13.9 miles, an average speed of 20.5 mph
- This can also be used to better understand arterial displays

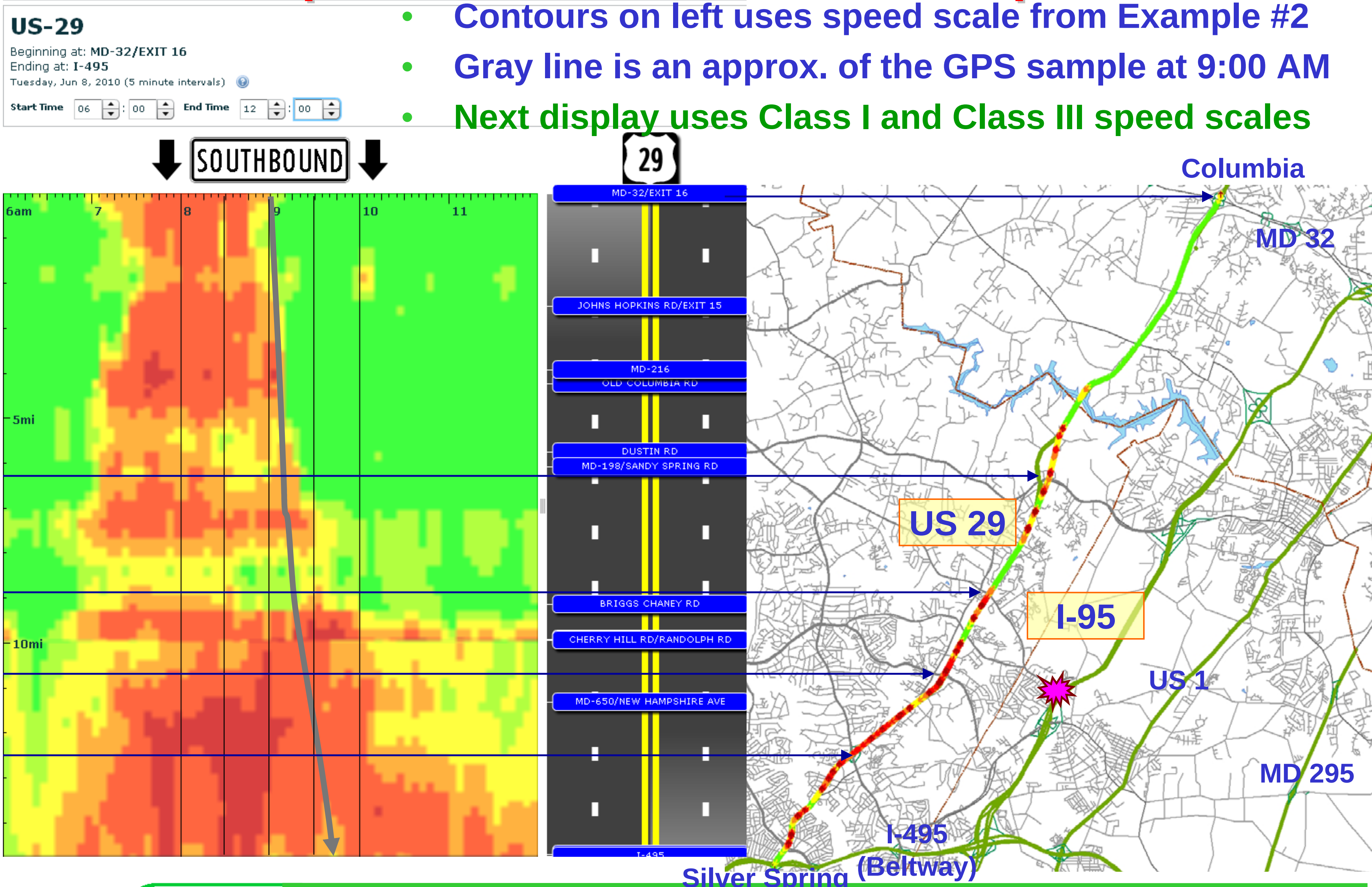


Example #3: Direct impact of the incident on traffic on I-95 (Freeway) southbound



Use Example to Fine-Tune Arterial Representation

- Contours on left uses speed scale from Example #2
- Gray line is an approx. of the GPS sample at 9:00 AM
- Next display uses Class I and Class III speed scales



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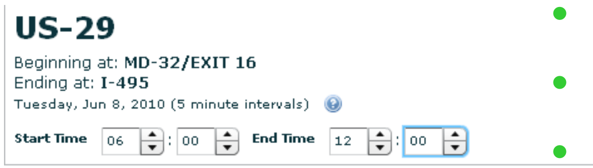
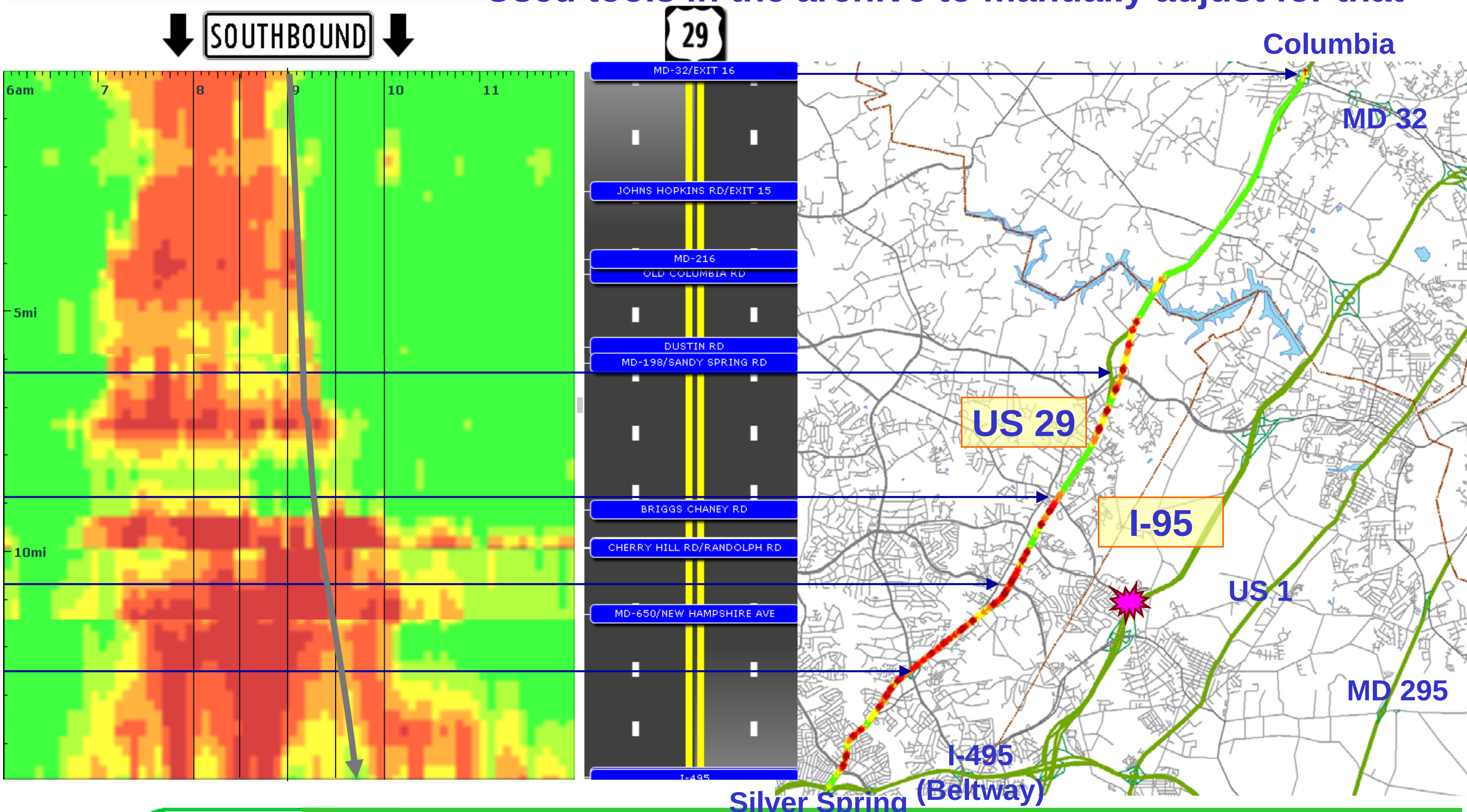
Same Example Using Arterial Speed Scales

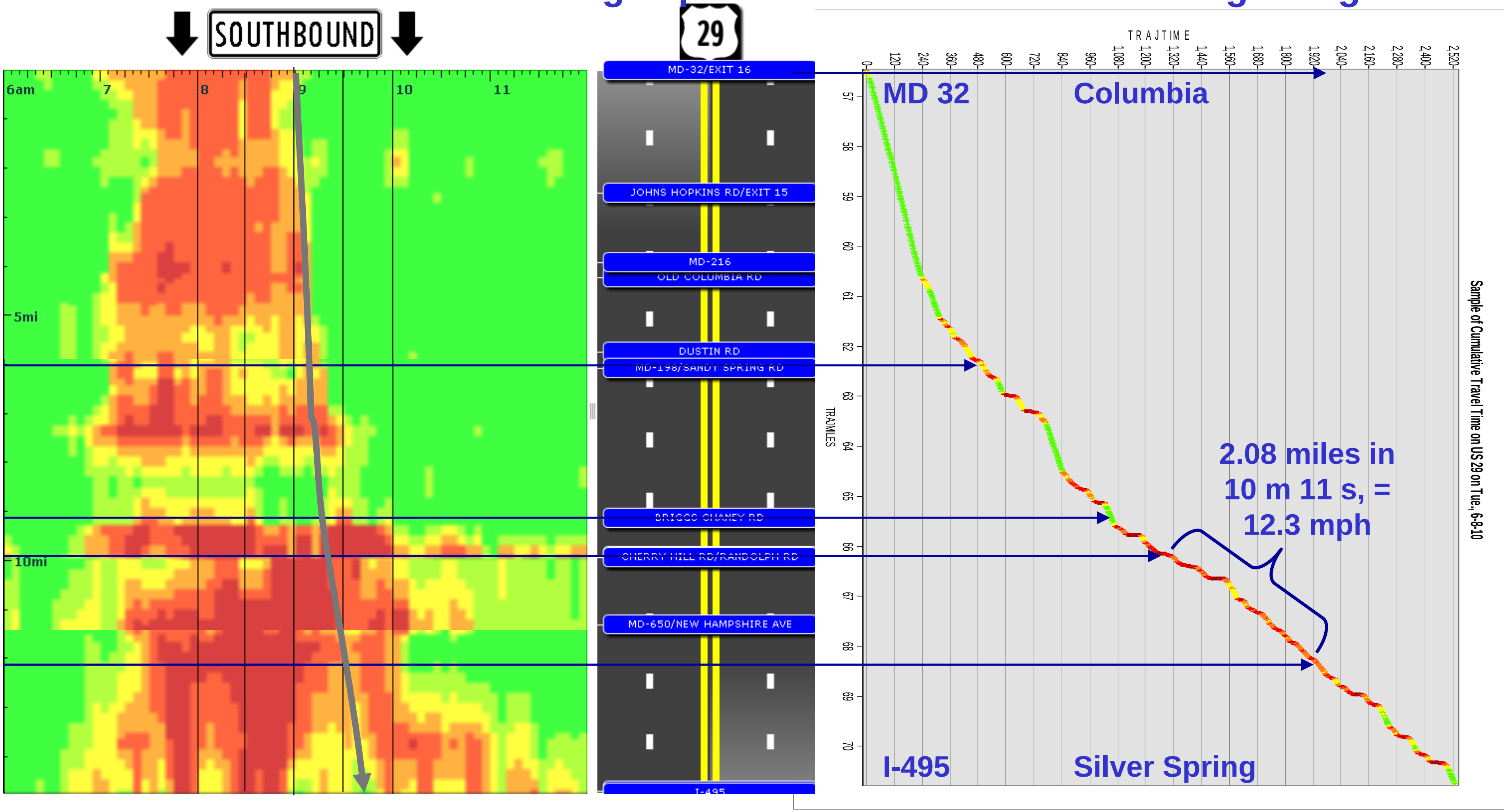


- US 29 from MD 198 to MD 650 is a Class I Arterial
- From MD 650 to I-495 it is a Class III Arterial
- Used tools in the archive to manually adjust for that



GPS Sample Displayed as a Time-Distance Graph

- Interrupted flows (stops) shown as horizontal lines
- Slopes for short sections of the line are spot-speeds
- Average speed can be calculated for longer segments



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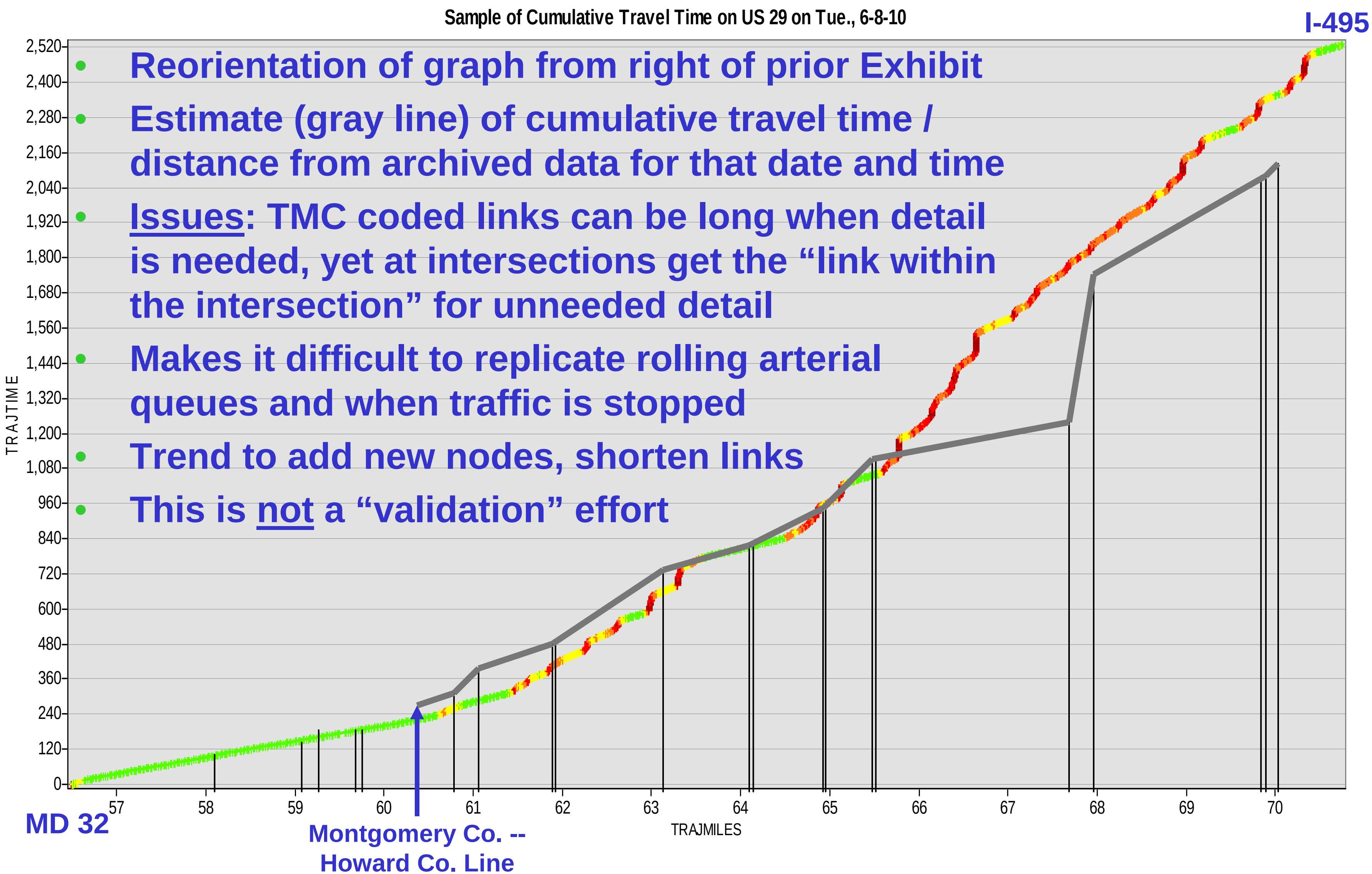
GPS Sample Contrasted to Archived Data for Date



- Reorientation of graph from right of prior Exhibit
- Estimate (gray line) of cumulative travel time / distance from archived data for that date and time
- Issues: TMC coded links can be long when detail is needed, yet at intersections get the “link within the intersection” for unneeded detail
- Makes it difficult to replicate rolling arterial queues and when traffic is stopped
- Trend to add new nodes, shorten links
- This is not a “validation” effort

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Summary and Conclusions

1. Scales of speed ranges used for speed maps and graphs of freeway congestion seem appropriate
2. Spatial-Temporal resolutions used for freeways helps to show recurring and incident related congestion
3. Arterial data is starting to become more widely available
4. Research shows that it would be desirable to account for speed ranges for arterials that have slower speeds for congested conditions
5. Interrupted flow on arterials results in both rolling queues and standing queues at traffic signals
6. While link average speeds can be appropriate, also need a more congruent spatial-temporal resolution – a more even spacing of node-to-node to better match arterial speeds
7. More research on this is needed